Pedobiologia, Bd. 13, S. 28—39 (1973)

The Norwegian Forest Research Institute, N-1432 Ås-NLH

Biomass and body-surface area of populations of Enchytraeidae and Lumbricidae (Oligochaeta) in Norwegian coniferous forest soils[1])

GUNNAR ABRAHAMSEN

With 2 figures

(Accepted 12. IX. 1972)

(Keywords: vegetation types, soil profiles, textural classes, body length, live weight, seasonal variation, metabolism)

1. Introduction

Density of animal populations is given as number of individuals or biomass per unit area. Biomass often gives a more interesting description of the density than does the number of individuals, especially when different populations are compared. Where the density estimates are to be applied in studies of the productivity or metabolism of the population, the number of individuals alone is of no interest. As small animals have higher metabolism per unit body weight than larger animals, nor does the biomass alone give an adequate description of the population. However, for large groups of animals the basal metabolism per unit body-surface area seems to be constant (e. g. MACFADYEN 1963, GANONG 1969). This means that the total body-surface area of the population may give a much more interesting description of the population than both abundance and biomass. By analogy to the term biomass, the total body-surface area of the population is designated bio-surface area in the present study.

In a previous study (ABRAHAMSEN 1972) a non gravimetric method was established to estimate the live weight of Enchytraeidae. As a by-product a method for estimating the body-surface area was obtained. In the present study these results have been applied to density estimates of Enchytraeidae and Lumbricidae previously published (ABRAHAMSEN 1972a and b). The present paper, therefore, reports the biomass and bio-surface area of these animals in different soils and below various ground cover vegetation in coniferous forests. Although the actual relationship between body-surface area and basal metabolism for these oligochaete worms is unknown, this information together with the biomass estimates are considered relevant to the quantification of the importance of enchytraeids and earthworms on the cycles of plant nutrients in the soil.

2. Study areas and sample plots

The sample plots have been described previously (ABRAHAMSEN 1972a) and require only a brief description in the present paper. In three areas in South-Eastern Norway sample plots were placed in different vegetation types in coniferous forests. In relation to Oslo, area A is situated 30 km south, area B 60 km north and area C is ca. 85 km south-west. Annual normal air temperature and precipitation for the study areas appear from Table 1.

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[1]) Contribution from the Forest Soil Fertilization Research Group.

Table 1 Approximate dates of yearly normal air temperature and precipitation for the study areas

Study area	Temperature (°C)	Precipitation (mm)	General climate
A	5.5	870	Humid
B	3.3	1080	Superhumid
C	3.8	1300	Superhumid

The designation of the general climate is according to HESSELMAN (1932).

Characteristics of the vegetation and soil of the sample plots are given in Table 2. It should be noticed that two sample plots in area A had been placed on the same vegetation type, viz. the Melico-Piceetum typical subassociation. These sample plots were slightly different with regard to humus, soil profile and age of the trees. The designation of the textural classes is based on the soil texture triangle of the U.S. Department of Agriculture (e. g. KOHNKE 1968).

The studies were carried out during the years 1967 to 1969. It is important to stress that the sampling was not carried out simultaneously in the different areas. The same applies to the studies on the enchytraeids and earthworms.

3. Methods

In connection with the previous study (ABRAHAMSEN 1972a) the length distribution of the enchytraeid species was estimated by means of microphotographs of live specimens. In the present study the mean live weight and the mean body-surface area of the size groups have been derived from the regressions previously described between body-length and live weight and between body-length and body-surface area (ABRAHAMSEN 1973). Concerning two species viz. *Mesenchytraeus armatus* LEVINSEN, 1884, and *Fredericia galba* (HOFFMEISTER, 1843) for which no such regression were established, the biomasses and bio-surface areas have been estimated by using the regression of group F in the previous study.

When the previous study of earthworms was carried out (ABRAHAMSEN 1972b) an appropriate balance was not easily accessible. Therefore, earthworms extracted from the soil were not weighed before preservation in 5 per cent formalin solution. An estimation of the biomass (live weight) of the worms was later made possible by establishing regressions between live weight and length of preserved worms (Fig. 1). These regressions were estimated by weighing 144 live earthworm specimens which had emptied their guts after staying without food for 48 hours. The length measurements took place after a couple of days' preservation in 5 per cent formalin solution. The regression between live weight and body-length found by EDWARDS (1967) gives lower weights for specimens shorter than 10 cm than do the regressions in the present study. The correlation coefficient in EDWARDS' study is lower than in the present study. This is to be expected since EDWARDS probably did not discriminate between species and also since the length was measured on live specimens. The variation in length of live specimens is probably much greater than in preserved ones.

The body-surface area of the earthworms was estimated by assuming the same average relation between length (L), volume (V), and body-surface area (A) as previously found for enchytraeids (ABRAHAMSEN 1973). If enchytraeids are considered to be cylinder shaped the lateral surface area is $A = 2\sqrt{\pi \cdot V \cdot L}$. This area appeared to be in average ca. 3 per cent larger than the body-surface area calculated by means of Simpson's formula (ABRAHAMSEN 1973). This means that the body-surface area of earthworms may be estimated by the formula $1.94\sqrt{\pi \cdot V \cdot L}$. The volume of the earthworms can be found when density (specific gravity) and weight are known. The density of a small number of earthworms was measured in Ficoll which is a high molecular weight polymer (MW 400.000) of sucrose. The procedure was as previously used for enchytraeids (ABRAHAMSEN 1973). The average density of the earthworms (without gut content) was ca. 1.04 g/cm³. EDWARDS (1967) found a density of 1.064 g/cm³, but this density is most probably too high since the measurements were carried out in highly hypertonic glycerol solustions. The difference in density of earthworms when measured in glycerol or Ficol solutions is approximately as previously established for enchytraeids (ABRAHAMSEN 1973). The body-surface area of individual earthworms in the present study has, therefore, been estimated by means of the formula

$$A = 1.9\sqrt{\pi \cdot W \cdot L}$$

where W is the live weight and L the length of preserved worms.

Table 2 Description of vegetation[1]), altitude, and soil of the sample plots

Vegetation types																		
Association:	Cl-Pn	Ba-Pn		Va-Pn			Eu-Pc			Eu-Pc		Me-Pc				Me-Pc		
Subassociation:							My			Dr		ty				At		
Study area:	A	B	C	A	B	C	A	B	C	B	C	A_1	A_2	B	C	A	B	C
Altitude (m)	100	530	470	100	330	450	100	500	450	330	470	100	100	400	470	100	400	450
Cover of tree layer (%)	*20*	*10*	*0*	*40*	*50*	*30*	*40*	*10*	*10*	*10*	*50*	*60*	*60*	*40*	*10*	*60*	*10*	*40*
Age of forest	110	—	—	110	50	70	90	100	80	100	80	50	85	110	90	50	100	40
Soil profile	Raw humus upon rocks			← Iron podsols →								Brown earth	← Semi-podsol →			Brown earth		
Humus	7 cm	8 cm	8—10 cm	← 5—7 cm raw humus layer →								Mull	← Moder →			Mull		
Textural classes	—	—	—	Loamy sand	Sandy loam	Loamy sand	Sandy loam	Silt loam	← Sandy loam →							Loam	Loam	Sandy loam

Abbreviations: (Cl-Pn) Cladonia Pinetum; (Ba-Pn) Barbilophozio Pinetum; (Va-Pn) Vaccinion Pinetum; (Eu-Pc My) Eu-Piceetum Myrtillus; (Eu-Pc Dr) Eu-Piceetum Dryopteris; (Me-Pc ty) Melico-Piceetum typical; (Me-Pc At) Melico Piceetum Athyrium.

1) Description of the vegetation types is given by Dahl et al. (1967) and reviewed by Abrahamsen (1972 a).

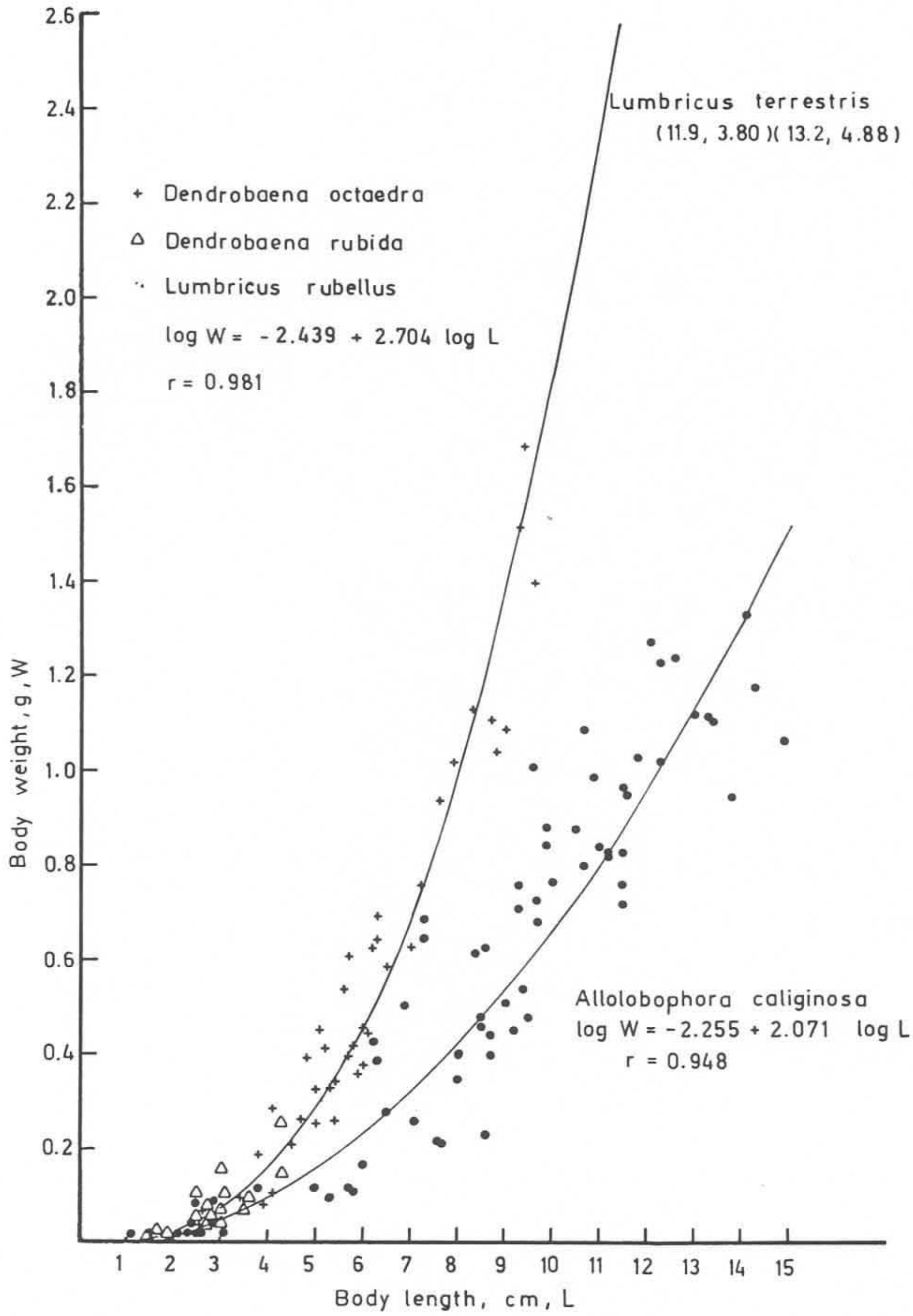

Fig. 1. Relation between body-length of preserved earthworms (5 % formalin solution) and their live weight. Note: the symbol • refers to *Allolobophora caliginosa* and the symbols + refers to both *Dendrobaena octaedra* and *Lumbricus rubellus*.

4. Results

Table 3 gives the average length distributions of the enchytraeid species which from a biomass point of view were most important at the individual vegetation types. For each length class the corresponding mean live weight and mean body-surface area are registered. Table 4 gives the corresponding length distributions of the earthworms extracted by means of the Baermann funnels. The variation in length of earthworms among the sampling dates at the **Me-Pc ty** A_1, sample plot appears in Table 5. The length distributions presented in Table 3 and 4 are only approximate as they are the estimated average of the length distributions of various populations. Computing of the oligochaete

Table 3 Average length class distribution of the enchytraeid species with the highest biomass. The mean live weight (μg) and the mean body surface area (mm^2) of the length classes are also given

	Length class (mm)				
	0— 1.00	1.01— 2.00	2.01— 3.00	3.01— 4.00	4.01— 5.00
Enchytronia parva NIELSEN and CHRSTENSEN, 1959	7	50	37	6	
Marionina argentea (MICHAELSEN, 1889)	37	63	—	—	
Mean weight	1	9	25	43	
Mean body surface area	0.09	0.39	0.79	1.27	
Enchytraeus buchholzi VEJDOVSKY, 1879	—	60	30	10	
Mean weight	2	11	30	59	
Mean body surface area	0.10	0.49	1.05	1.80	

	Length class (mm)							
	0— 2.0	2.1— 4.0	4.1— 6.0	6.1— 8.0	8.1— 10.0	10.1— 12.0	12.1— 14.0	14.0
Cognettia sphagnetorum (VEJDOVSKY, 1877)	7	40	35	10	5	3		
Buchholzia appendiculata (BUCHHOLZ, 1862)	13	45	35	7	—	—		
Mean weight	11	51	111	185	272	370		
Mean body surface area	0.35	1.32	2.5	3.8	5.3	6.8		
Mesenchytraeus spp.	2	25	20	20	15	10	4	4
Fredericia galba (HOFFMEISTER, 1843) and *F. ratzeli* (EISEN, 1872)	—	1	7	2	10	5	5	70
Mean weight	9	74	220	450	780	1210	1740	2380
Mean body surface area	0.31	1.58	3.5	6.0	8.9	12.3	16.0	20.0
Fredericia bisetosa (LEVINSEN, 1884)	4	27	10	13	4	15	17	10
Mean weight	9	63	170	325	530	790	1100	1470
Mean body surface area	0.31	1.45	3.1	5.1	7.4	10.0	12.8	15.8

Table 4 Average length class distribution of the earthworm species. The mean live weight (mg) and the mean body-surface areas (cm^2) are als given

	Length class (cm)					
	0– 1.0	1.1– 2.0	2.1– 3.0	3.1– 4.0	4.1– 5.0	5.1– 6.0
Dendrobaena octaedra (SAVIGNY, 1826)	3	38	33	19	3	4
D. rubida (SAVIGNY, 1826)	—	30	—	—	36	34
Mean weight	1	12	44	107	210	360
Mean body-surface area	0.08	0.45	1.12	2.1	3.3	4.7

	Lenght class (cm)							
	2.0	2.1– 4.0	4.1– 6.0	6.1– 8.0	8.1– 10.0	10.1– 12.0	12.1– 14.0	14.0
Lumbricus rubellus HOFFMEISTER, 1843	28	53	7	10	2			
Mean weight	6	75	283	695	1390			
Mean body-surface area	0.29	1.63	4.0	7.4	11.9			
Allolobophora caliginosa (SAVIGNY, 1826)	7	38	35	5	8	3	2	2
A. rosea (SAVIGNY, 1826)	—	—	50	50	—	—	—	—
Mean weight	8	56	158	315	530	800	1130	1520
Mean body-surface area	0.33	1.42	3.0	5.0	7.4	10.0	13.0	16.0

Table 5 Seasonal variation in length class distribution of the earthworms at the **Me-Pc ty** A_1 sample plot. The live weight and body-surface area corresponding to the length classes appear from Table 4

Species	Sampling date	Length class (cm)						
		0—2.0	2.1—4.0	4.1—6.0	6.1—8.0	8.1—10.0	10.1—12.0	12.1—14.0
Allolobophora caliginosa	June 1	5	40	15	15	25	—	
	July 1	—	11	32	16	21	10	10
	Aug. 1	22	17	33	17	6	5	
	Sept. 1	10	40	20	20	—	10	
	Oct. 1	—	55	18	—	18	9	
	Nov. 1	—	83	—	—	—	17	
Lumbricus rubellus	June 1	24	64	4	8	—		
	July 1	25	60	6	3	6		
	Aug. 1	19	62	14	—	5		
	Sept. 1	5	43	42	10	—		
	Oct. 1	4	32	60	4	—		
	Nov. 1	5	19	52	14	10		
		Length class (cm)						
		0—1.0	1.1—2.0	2.1—3.0	3.1—4.0	4.1—5.0	5.1—6.0	
Dendrobaena octaedra and Dendrobaena rubida	All dates	7	30	36	16	8	3	

Table 6 Enchytraeid biomass and bio-surface areas at the different vegetation types, study areas, and sampling dates

Study area and sampling data	Vegetation types							
	Cl-Pn	Ba-Pn	Va-Pn	Eu-Pc My	Eu-Pc Dr	Me-Pc ty		Me-Pc At
I								
A, Sept. 3 1967	4.67		2.72	3.35		2.60[1])	3.84[2])	1.59
A, Oct. 25 1967	5.78		3.98	5.60		3.94[1])	3.80[2])	1.18
B, June 11 1968		2.15	0.08	4.58	4.96	3.24		1.34
C, July 28 1968		1.49	1.84	6.67	4.62	1.64		8.86
Mean	5.23	1.82	2.16	5.05	4.79	3.18		3.33
II								
A, Sept. 3 1967	9.97		5.63	7.14		5.82[1])	8.67[2])	2.89
A, Oct. 25 1967	12.12		8.11	11.23		8.23[1])	8.21[2])	2.09
B, June 11 1968		4.74	0.17	10.13	10.89	6.83		2.63
C, July 28 1968		3.40	4.43	15.65	10.42	3.42		13.14
Mean	11.05	4.07	4.59	11.04	10.66	6.86		5.19

(I) Biomass g/m^2, (II) Bio-surface area dm^2/m^2. [1]) Sample plot A_1; [2]) Sample plot A_2.

Table 7 Earthworm biomass and bio-surface areas at the different vegetation types, study areas and sampling dates

Study area	Sampling date	Extraction method 3)	Va-Pn	Eu-Pc My	Eu-Pc Dr	Me-Pc	ty	Me-Pc At
I								
A	Oct. 14—15 1968	Form.	0.49	5.33		10.6 1)	14.9 2)	15.3
A	June 1 1969	BF	0	0.57		44.9 1)	38.9 2)	50.8
B	Oct. 14 1969	BF	0	1.35	0.37	15.3		14.6
C	Sept. 2 1969	BF	0	4.70	4.82	16.2		29.2
Mean			0.12	2.99	2.60	23.5		27.5
II								
A	Oct. 14—15 1968	Form.	0.06	0.65		1.64 1)	2.21 2)	2.12
A	June 1 1969	BF	0	0.17		7.02 1)	4.91 2)	7.08
B	Oct. 14 1969	BF	0	0.33	0.14	2.41		2.54
C	Sept. 2 1969	BF	0	0.72	0.86	2.67		4.53
Mean			0.02	0.47	0.50	3.48		4.07

(I) Biomass g/m^2. (II) Bio-surface-area dm^2/m^2. 1) Sample plot A_1; 2) Sample plot A_2; 3) Form — formaline, BF — Baermann funnels.

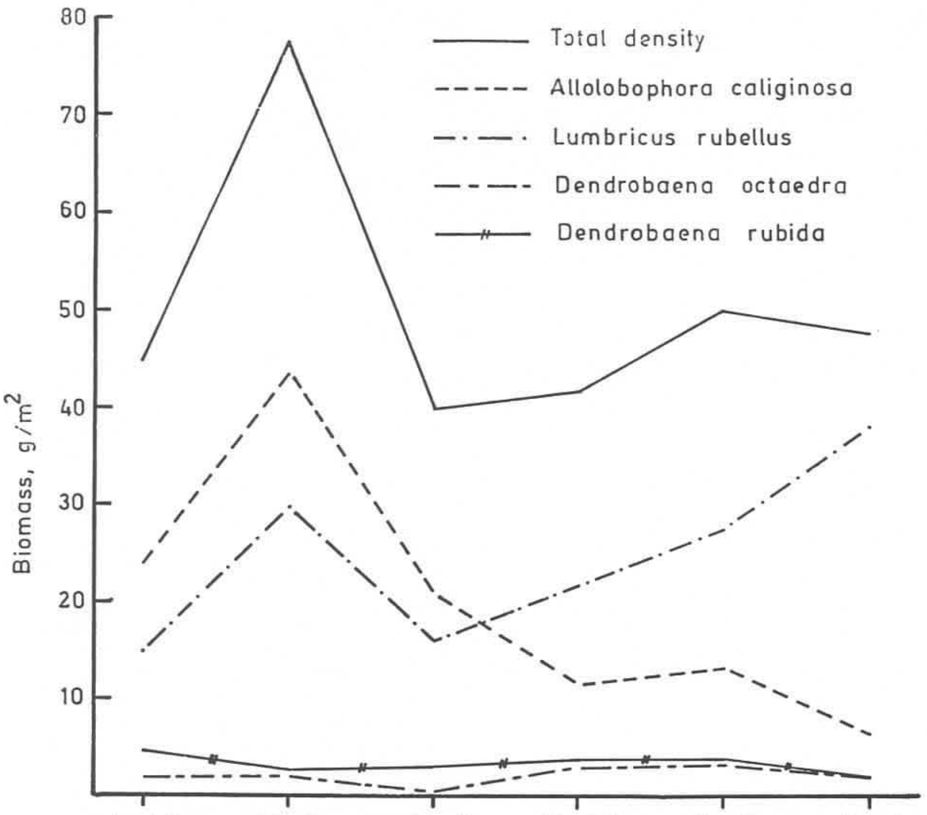

Fig. 2. Variation in earthworm biomass among sampling dates at the **Me-Pc ty** A_1 sample plot.

biomasses and bio-surface areas (Table 6 and 7) was, however, based on the size distributions of the specific populations.

It appears from Table 6 that data on biomass and bio-surface areas of enchytraeids are not given for the two first samples collected in area *A* (See Abrahamsen 1972a). The reason is that estimates of the biomass for these samples were intended to be based on the method used by Nielsen (1955). This method was, however, laborious and difficult to standardize. It was, therefore, abandoned and the results have not been used. Data on the "seasonal" variation in enchytraeid biomasses and bio-surface areas are consequently reduced to the two last sampling dates viz. September 3 and October 25, 1967. It should be stressed that comparisons of biomasses and bio-surface areas among the study areas and also between enchytraeids and earthworms are of slight interest due to different sampling dates.

Variation in earthworm biomass among the sampling dates at the **Me-Pc ty A_1** is shown in Figure 2. The variation in bio-surface area was almost identical. The highest and lowest figure for all earthworm species were 10.5 dm^2/m^2 and 6 dm^2/m^2 respectively.

The average biomass of some important species (from a biomass and bio-surface area point of view) as percentage of the total enchytraeid or earthworm biomass at the different vegetation types (Table 6 and 7), are shown in Table 8 and 9 respectively. It is stressed that the variation in biomass of the individual species among the study areas was very great, especially at the **Me-Pc At** sample plots. *Fredericia galba* constituted for example 60 % of the biomass of enchytraeids at the **Me-Pc At** sample plot in area *A*. At the same vegetation type in area *B* the species was at all not recorded.

Table 8 The average biomass of the most important enchytraeid species as percentage of the total average enchytraeid biomass at the individual vegetation types

	Vegetation type						
	Ce-Pn	Ba-Pn	Va-Pn	Eu-Pc My	Eu-Pc Dr	Me-Pc ty	Me-Pc At
Cognettia sphagnetorum	←		94		→	73	4
Mesenchytraeus glandulosus							
M. pelicensis	←		6		→	15	3
M. flavus						—	—
Enchytronia parva						7	2
Fredericia galba						—	30
F. bisetosa						—	25
Mesenchytraeus armatus						—	14
Marionina argentea						—	5
Buchholzia appendiculata						—	4
Fredericia ratzeli						—	4
Enchytraeus buchholzi						—	4
Other spezies						5	5

Table 9 The average biomass of the earthworm species as percentage of the total average earthworm biomass at the individual vegetation types

	Vegetation type				
	Va-Pn[1]	Eu-Pc My	Eu-Pc Dr	Me-Pc ty	Me-Pc At
Dendrobaena octaedra	20	95	50	15	1
Lumbricus rubellus	80	5	30	40	22
Dendrobaena rubida			20	5	—
Allolobophora caliginosa				40	75
A. rosea					2

[1] The figures from the Va-Pn are derived from the formalin extraction, the other from the extraction in the Baermann funnels.

5. Discussion

The population densities of enchytraeids and earthworms in Norwegian coniferous forest soils have previously been given as number of individuals (ABRAHAMSEN 1972a and b). By presenting the densities as biomass the relative densities of small species have been reduced, and the relative densities of large species have been increased. This means that compared with the previous studies the relative densities presented in the present studies are lower for species like, *Enchytronia parva*, *Enchytraeus buchholzi*, *Marionina argentea*, and *Dendrobaena* spp. The dominance of *Mesenchytraeus* spp., *Fredericia bisetosa*, *Fredericia galba*, *Fredericia ratzeli* and *Allolobophora caliginosa* is, on the other hand, greater in the present study. The dominance of the different species was more similar to the relative abundance when measured by bio-surface area than by biomass.

The relative population densities of the oligochaete worms among the vegetation types also depend on the means of expression. Using the number of individuals, the enchytraeids were most abundant at the **Eu-Pc**, the **Me-Pc ty** and also at the **Cl-Pn**. When the density is given as biomass or bio-surface area the relative density at the **Me-Pc ty** is reduced. The highest biomass and bio-surface areas are found in the **Eu-Pc** and the **Cl-Pn** associations. However, there are differences between the biomass and bio-surface area in this respect. In area *C* the highest biomass was found at the **Me-Pc At**, but the highest bio-surface area at the **Eu-Pc My**.

As the basal metabolic rate seems approximately proportional to the body-surface area of a wide range of organisms (e. g. MACFADYEN 1963, GANONG 1969) the conclusions given above indicate that the highest metabolic activity of the enchytraeid populations in coniferous forests was in the oligotrophic spruce forest soils and in the **Cl-Pn** association. The latter vegetation type is very poor from a plant nutrient point of view. This implies relatively small litter production and, consequently, limited food supply for the soil organisms. On this background the high enchytraeid metabolism indicated is surprising. The enchytraeids may, however, on this particular vegetation type be relatively more abundant than other soil animals. This vegetation type also had a very shallow soil layer (ca. 7 cm) and a sparse tree cover (ca. 20 per cent). This generally involves higher soil temperature than in the soil of the other vegetation types. With adequate soil moisture (as in the sampling year) the breeding rate will be high, and so will, consequently, also the population densities.

Independent of the expression of density the earthworm populations were most abundant at the richest spruce forest soils. The density differences between the two **Me-Pc** subassociations were small. In years with low precipitation, however, more pronounced differences are to be expected since the **Me-Pc ty** is a dry type and the **Me-Pc At** subassociation is a moist type often influenced by seeping water (DAHL et al. 1967).

It is interesting to note that in the brown earth of the **Me-Pc At** where the average biomass of enchytraeids and earthworms was 3.3 and 27.5 g/m^2, respectively, the average corresponding bio-surface areas were 5.2 and 4.1 dm^2/m^2. Similarily at the **Me-Pc ty** the enchytraeid bio-surface area was in average approximately 2 times greater than the earthworm bio-surface area despite a 7 times greater biomass of earthworms than of enchytraeids. This clearly demonstrates the great surface area of small animals. With reservation regarding the different sampling dates, this indicates that the metabolism is higher for enchytraeids than for earthworms in coniferous forest soils in Southern Norway.

To the author's knowledge no papers have been published regarding the body-surface area of oligochaeta. Biomass studies, however, have been carried out in coniferous forests in Denmark (BORNEBUSCH 1930, NIELSEN 1955) and England (REYNOLDSON 1955, O'Connor 1963). Bornebusch's and Reynoldson's studies showed earthworm biomass in raw humus coniferous forest of the same magnitude as reported in the present study. Bornebusch's biomass data in mull coniferous forests were on the other hand, only 7 to 50 per cent of the corresponding biomass in the present study. The earthworm biomass estimates of the Melico-Piceetum association are of the same magnitude as those reported from Norwegian arable soil (Uhlen 1953).

Bornebusch (1930) observed higher numbers and biomass of enchytraeids in raw humus than in mull soils of coniferous forests. His actual figures are, however, of little interest due to inefficient extraction method. Nielsen (1955) and O'Connor (1963), by highly efficient extraction methods, found biomass between 3 and 25 g/m^2 in raw humus conifer plantations. Nielsen also observed higher enchytraeid biomass in raw humus than in any of the other localities (bogs, pastures, deciduous forests). These observations were supported by Peachey's (1963) study from moorland soils in England where biomass between 10 and 53 g/m^2 were found.

The biomass of other soil animals in coniferous forests is only sparsely investigated. Weis-Fogh (1947–1948) and Nielsen (1949) found, however, according to Nielsen (1955), biomasses of microarthropods and nematodes corresponding to 11 and 4–5 g/m^2 at habitats in conifer plantations identical or comparable to those examined by Nielsen (1955).

The vertical distribution in biomass and bio-surface area observed in the present study was generally similar to the vertical distribution in numbers. Only at the **Me-Pc** ty the bio-surface area and especially the biomass distribution was more concentrated in the surface layers of the soil than the distribution in numbers previously shown (Abrahamsen 1972a). The reason is that this particular vegetation type was inhabited by large numbers of small euedaphic species. These species had a greater influence on the vertical distribution when given as numbers than when given as bio-surface area and biomass.

For several reasons no attempt has been made in the present study to estimate the oxygen consumption of the oligochaete populations. The most important reason is that the estimates of the oxygen consumption would only be examples of the respiration. These examples could not be related to the annual litter production or to the proportion of the total oxygen consumption of soil organisms consumed by the oligochaete fauna. Nevertheless such examples of oxygen consumption may have some interest. Therefore, approximate size class distributions of the different species have been given. These distributions together with the biomass figures can be used to compute the respiration of enchytraeid and earthworm populations when respiration data for all abundant species in the present study are available.

6. Summary · Zusammenfassung

The biomass and body-surface area of populations of Enchytraeidae and Lumbricidae have been studied in different soils and below different ground cover vegetations in coniferous forests in Southern Norway.

The highest biomass (8.9 g/m^2) and body-surface area (15.7 dm^2/m^2) of enchytraeids were in general found in the podzol soils of the oligotrophic spruce forests and in one of the poorest pine forests — the Cladonio-Pinetum association.

The highest biomass (50.8 g/m^2) and body-surface area (7.1 dm^2/m^2) of earthworms were found in the nutritious brown earth and semipodzols of the spruce forests.

In spite of considerably higher biomass of earthworms than of enchytraeids in the nutritious spruce forest soils, the body-surface area was in general noticeably higher for the enchytraeid populations than for the earthworm populations. This indicates that the metabolism of enchytraeids may be more significant than that of earthworms in coniferous forest soils in Southern Norway.

[Biomasse und Körperoberfläche von Enchytraeiden- und Lumbriciden-Populationen in norwegischen Nadelwald-Böden]

Die Biomasse und die Körperoberfläche von Enchytraeiden- und Lumbriciden-Populationen wurde in verschiedenen Böden und unter verschiedener Bodenvegetation in Nadelwäldern Süd-Norwegens untersucht.

Die größte Biomasse (8,9 g/m²) und die größte Populations-Körperoberfläche (15,7 dm²/m²) von Enchytraeiden wurde im allgemeinen in den Podzolböden oligotropher Fichtenwälder und in einem der ärmsten Kiefern-Forste (Cladonio-Pinetum) gefunden.

Die größte Biomasse (50,8 g/m²) und Populations-Körperoberfläche (7,1 dm²/m²) von Regenwürmern wurden in der nährstoffreichen Braunerde und in Semipodzolen der Fichtenwälder gefunden.

Trotz der beträchtlich höheren Biomasse der Regenwürmer in den nährstoffreichen Fichtenwald-Böden, war die Populations-Körperoberfläche der Enchytraeiden beachtlich größer als die der Lumbriciden. Dies weist darauf hin, daß der Metabolismus der Enchytraeiden in Nadelwäldern Süd-Norwegens bedeutungsvoller als der der Regenwürmer ist.

7. Literature

Abrahamsen, G., 1972a. Ecological study of Enchytraeidae (Oligochaeta) in Norwegian coniferous forest soils. Pedobiologia **12**, 26–82.

Abrahamsen, G., 1972b. Ecological study of Lumbricidae (Oligochaeta) in Norwegian coniferous forest soils. Pedobiologia **12**, 267–281.

Abrahamsen, G., 1973. Studies on body-volume, body-surface area, density and live weight of Enchytraeidae (Oligochaeta). Pedobiologia **13**, 1, 6–15.

Bornebusch, C. H., 1930. The fauna of forest soil. Forst. Fors Væs. Danm. **11**, 1–158.

Dahl, E., O. Gjems and J. Kielland-Lund, 1967. On the vegetation types of Norwegian conifer forests in relation to the chemical properties of the humus layer. Meddr norske SkogforsVes. **23**, 501–531.

Edwards, C. A., 1967. Relationships between weights, volumes and numbers of soil animals. In: Graff, O., and J. E. Satchell (eds.): Progress in soil biology. 584–594. Friedr. Vieweg & Sohn GmbH, Braunschweig, and North-Holland Publishing Company, Amsterdam.

Ganong, W. F., 1969. Review of medical physiology. Blackwell Scientific Publications, Oxford and Edinburg, 628 pp.

Hesselman, H., 1932. Om klimaets humiditet i vårt land och dess inverkan på mark, vegetation och skog. Meddn St. SkogsförsAnst. **26**, 515–559.

Kohnke, H., 1968. Soil physics. McGraw Hill Book Company, New York, 224 pp.

Macfadyen, A., 1963. Animal ecology, aims and methods. Sir Isaac Pitman & Sons Ltd. London, 344 pp.

Nielsen, C. O., 1949. Studies on the soil microfauna. II. The soil inhabiting nematodes. Natura jutl. **2**, 1–131.

Nielsen, C. O., 1955. Studies on Enchytraeidae. 2. Field studies. Natura jutl. **4/5**, 1–58.

O'Connor, F. B., 1963. Oxygen consumption and population metabolism of some populations of Enchytraeidae from North Wales. In: Doeksen, J., and J. van der Drift (eds.): Soil Organisms. 32–48. North-Holland Publishing Company, Amsterdam.

Peachey, J. E., 1963. Studies on the Enchytraeidae (Oligochaeta) of moorland soil. Pedobiologia **2**, 81–95.

Reynoldson, T. B., 1955. Observations on the earthworms of North Wales. NWest. Nat. **3**, 291–304.

Uhlen, G., 1953. Orienterende forsøk med meitemark. [Preliminary experiments with earthworms]. Fors. Landbr. **37**, 161–183.

Weis-Fogh, T., 1947/48. Ecological investigations on mites and collemboles in the soil. Natura jutl. **1**, 135–270.

Address of the author: Gunnar Abrahamsen, Norwegian Forest Research Institute, Section of Forest Pathology and Entomology, P. O. Box 62, N-1432 Ås-NLH, Norway.